A METHOD FOR DETERMINING AN ADJUSTMENT AMOUNT TO AN INPUT CHROMA

RELATED APPLICATIONS

Cross reference is made to the following applications filed concurrently herewith: Attorney Docket Number D/A2068 entitled "A METHOD FOR DETERMINING A HUE ADJUSTMENT TO AN INPUT HUE" by Karen M. Braun; and Attorney Docket Number D/A2068Q entitled "A METHOD FOR SQUEEZING

5   AN INPUT HUE TOWARD A REGION OF PREFERRED HUE" by Karen M. Braun.

FIELD OF THE INVENTION

The present invention generally relates to methods for converting color values and, more particularly, to methods for adjusting input colors in the direction of a specified output color to improve image appearance.

BACKGROUND OF THE INVENTION

10   Film companies are known to change certain colors to, for instance, show skin more tanned or the sky a different shade of blue. This is relatively easy when one has control over most every aspect of the image capturing and image production process. However, when the input image has been captured and rendered in an unknown way, improving certain colors therein becomes more

15   complicated. This often involves segmenting colors believed to make up a certain color then adjusting these toward a preferred color point. This is computationally intensive, subject to failure, and often results in non-smooth transitions between different color regions such as skin color and non-skin color areas.

20   Another approach is to specify both original and desired color and then apply a vector from original to desired color with the effect of the vector smoothly decaying for nearby colors in color space. One problem with this approach is

non-monotonic behavior leading to color reversals. Other techniques involve a weighting function for transforming a color to a new color and smoothly adjusting surrounding colors without inducing any tone reversals using a Gaussian weight on the difference between the input and the desired output. This method also uses a conditional function to insure monotonicity of the input to output relationship. Another technique transforms an input color to a desired output color and colors surrounding the input color are appropriately warped to give smooth and monotonic output using a concept of color gravity wells toward which other colors are adjusted. However, this technique is specific to neutrals and pure primaries and secondaries.

What is needed in this art is a method for adjusting input colors in the direction of a specified output color to improve image appearance that acts on colors in color space rather than adjusting the colors of certain pixels spatially to robustly render critical colors which are known a priori.

BRIEF SUMMARY

A method is disclosed for determining an adjustment amount to be made to an input chroma, C_{in}, to squeeze the input chroma toward a region of preferred chroma, C_{pref}. This method involving first defining a change in chroma as: $\Delta C = C_{in} - C_{pref}$ and defining a chroma weight such that the weight approaches 1 at the peak of the Gaussian as: $C_{weight} = Gaussian(C_{pref}, C_{sigma})$. Then, an amount of chroma adjustment is then: $C_{Adjust} = \Delta C * C_{weight}$. An output chroma is generated by applying chroma adjustment to chroma input: $C_{out} = C_{in} - C_{Adjust}$. Similarly, disclosed is method for determining an adjustment amount to be made to an input lightness.

The present invention offers a plurality of advantages. For example, the input can also be squeezed toward a point in either RGB, a*b*, or u'v' space. Multiple hue centers can be use to sequentially squeeze the input toward a region of a preferred skin, sky, or grass. In the case of multiple squeezes, finite non-overlapping regions of support maintain the shifts from previous squeezes. The inputs can be pre-specified in a color management system or specified and provided dynamically. When squeezing is applied in a non-uniform way, a left

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side of a weighting curve and a right side of another are used to find regions of rapid decrease in quality for positive ΔH^*_{ab} renditions of certain tones.

DESCRIPTION OF THE SPECIFICATION

One method is disclosed for determining a hue adjustment to an input hue, H_{in}, to squeeze the input hue toward a region of preferred hue, H_{pref}. The method

5 involves obtaining a change in hue as: $\Delta H = H_{in} - H_{pref}$ and a hue weight such that the weight approaches 1 at the peak of the Gaussian as: $H_{weight} = Gaussian(H_{pref}, H_{sigma})$. An amount of hue adjustment is calculated by: $H_{Adjust} = \Delta H * H_{weight}$. Then, an output hue is generated by applying the adjustment such that: $H_{out} = H_{in} - H_{Adjust}$.

10 Change in hue, ΔH, is the difference between the input hue, H_{in} is the hue of a given pixel in the image (or node in the table) and the preferred hue, H_{pref}.

$$\Delta H = H_{in} - H_{pref}$$

$$H_{weight} = Gaussian(H_{pref}, H_{sigma})$$

$$H_{Adjust} = \Delta H * H_{weight}$$

15 $$H_{out} = H_{in} - H_{Adjust}$$

The weight approaches 1 at the peak of the Gaussian. When H_{in} is close to the preferred hue, H_{pref}, the ΔH causes the hue adjustment (H_{Adjust}) to be small so the output hue is very similar to the input hue (not rotated completely to the preferred hue). Hues very close to, or very far from, the preferred hue, get the

20 least amount of shift.

Also disclosed is a method for squeezing an input hue, H_{in}, toward a region of preferred hue, H_{pref}, having a preferred chroma, C_{pref}, and luminance, L_{pref}, to restrict the rotation effect to a point in LCH space rather than an entire hue slice. This method involving first defining a chroma weight as: $C_{weight} = Gaussian(C_{pref}, C_{sigma})$. Then, defining a luminance weight as: $L_{weight} = Gaussian(L_{pref}, L_{sigma})$. Defining a hue weight that approaches 1 at the peak of a Gaussian as: $H_{weight} = Gaussian(H_{pref}, H_{sigma})$. Defining an amount of hue adjustment as: $H_{Adjust} = \Delta H*(H_{weight}*C_{weight}*L_{weight})$. Then, generating an output hue by applying hue adjustment to hue input such that: $H_{out} = H_{in} - H_{Adjust}$.

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To restrict the rotation effect to be toward a point in LCH space, rather than toward an entire hue slice:

$$C_{weight} = Gaussian(C_{pref}, C_{sigma})$$

$$L_{weight} = Gaussian(L_{pref}, L_{sigma})$$

5 $$H_{weight} = Gaussian(H_{pref}, H_{sigma})$$

$$H_{Adjust} = \Delta H * (H_{weight} * C_{weight} * L_{weight})$$

$$H_{out} = H_{input} - H_{Adjust}$$

Alternately, the weighting function was altered to be a Gaussian was convolved with a Rect function, which allows independent control over how much

10 to adjust colors and how far away from H_{pref} to change the colors.

Preferably, the weighting function is replaced by the addition of two Gaussians, which allows additional flexibility over how colors are moved toward the preferred point by allowing additional parameters (K, M) for the adjustment.

$$weight\_tmp = e^{\frac{-(H\_in-M)^2}{2*H\_sigma^2}} + e^{\frac{-(H\_in+M)^2}{2*H\_sigma^2}}$$

15 $$H_{weight} = K * weight\_tmp / max(weight\_tmp)$$

The constant K in the second equation is adjusted such that no crossovers occur in hue. This parameter is adjusted such that the relationship between H_{out} and H_{in} is monotonically increasing.

Also disclosed is a method for determining an adjustment amount to be

20 made to an input chroma, C_{in}, to squeeze the input chroma toward a region of preferred chroma, C_{pref}. This method involving first defining a change in chroma as: $\Delta C = C_{in} - C_{pref}$ and defining a chroma weight as: $C_{weight} = Gaussian(C_{pref}, C_{sigma})$. Then, an amount of chroma adjustment is then: $C_{Adjust} = \Delta C * (H_{weight} * C_{weight} * L_{weight})$. An output chroma is generated by applying chroma

25 adjustment to chroma input:

$$C_{out} = C_{in} - C_{Adjust}.$$

The change in chroma, ΔC, is the difference between the chroma of interest, C_{in} and the preferred chroma, C_{pref}.

$$\Delta C = C_{in} - C_{pref}$$

$$C_{weight} = Gaussian(C_{pref}, C_{sigma})$$

$$L_{weight} = Gaussian(L_{pref}, L_{sigma})$$

$$H_{weight} = Gaussian(H_{pref}, H_{sigma})$$

$$C_{Adjust} = \Delta C * (H_{weight}{}^*C_{weight}{}^*L_{weight})$$

$$C_{out} = C_{in} - C_{Adjust}$$

Although the current description is directed toward three one-dimensional Gaussian functions, it is intended to also be directed toward a single three-dimensional Gaussian.

The present method is also extensible to squeezing colors toward a point in RGB space, a^*b^* (as opposed to h°/C^*) space, $u'v'$ space, etc.

Because of the sequential nature of the present method, colors are squeezed toward a point and not shifted directly to that point. Colors near the preferred point don't change much as the hue adjustment approaches 0, and this prevents hues from crossing the preferred point or hue reversals.

The present invention is additionally applicable for multiple hue centers, for example, to squeeze toward preferred skin, sky, and grass. This is done sequentially, but as each subsequent squeeze occurs, the former preferred points also be inadvertently shifted. Therefore, in the case of multiple squeezes, finite non-overlapping regions of support are defined making certain to produce smooth transitions between these regions. The squeezing is alternately applied in a non-uniform way, for example, to account for a rapid decrease in quality for positive ΔH^*_{ab} (yellow) renditions of skin tones. This only involves using the left side of one weighting curve and the right side of another; this is accomplished using two different values of H_{sigma}.

The present method can be applied in a device or in an abstract profile. The preferred colors can be pre-specified in the color management system or dynamically specified by the user.

Further advantages include no need for segmentation or other knowledge of input image; no need to specify original color or color vector; monotonicity (no crossovers), smoothness, and flexibility (e.g., the size of the region of surrounding colors this is affected by the "squeezing" can be varied).

5   While particular embodiments have been described, alternatives, modifications, variations, improvements, and substantial equivalents that are or may be presently unforeseen may arise to applicants or others skilled in the art. Accordingly, the appended claims as filed and as they may be amended are intended to embrace all such alternatives, modifications variations,

10 improvements, and substantial equivalents.